CLAIMS

Having thus described our invention in detail, what we claim as new and desire to secure by the Letters Patent is:

1. A method of improving the material quality of a defective semiconductor crystal material comprising the steps of:

amorphizing, partially or completely, a region of a defective semiconductor crystal material; and

thermally treating the amorphized region to recrystallize said partially or completely amorphized region forming a recrystallized region that has a reduced defect density as compared to the defective semiconductor crystal material.

2. The method of Claim 1 wherein the defective semiconductor crystal material is a heterostructure.

3. The method of Claim 1 wherein the defective semiconductor crystal material comprising a Si layer formed atop a SiGe alloy layer.

4. The method of Claim 3 wherein the Si layer is strained in a tensile manner, and the SiGe alloy layer is partially or completely relaxed.

5. The method of Claim 3 wherein the SiGe alloy layer is located atop a Ge resistant diffusion barrier layer.

6. The method of Claim 1 wherein the defective semiconductor crystal material comprises a semiconductor selected from the group consisting of Si, Si, SiGe, SiGeC, SiC, Ge, GaAs, InP, InAs, silicon-on-insulators, and SiGe-on-insulators.

7. The method of Claim 1 wherein said amorphizing is carried out using energetic ions.

8. The method of Claim 7 wherein said energetic ions are selected from the group consisting of B, Ga, In, C, Si, Ge, N, P, As, Sb, rare gas ions, and any isotope or mixtures thereof.

9. The method of Claim 7 wherein said energetic ions comprise Ge or its isotopes as the energetic ions.

10. The method of Claim 1 wherein said amorphizing is carried out by ion implantation.

11. The method of Claim 10 wherein the defective semiconductor crystal material is maintained at a temperature below 20°C during said ion implantation.

12. The method of Claim 1 wherein said amorphizing is carried out by plasma immersion implantation.

13. The method of Claim 1 wherein said amorphizing is carried out by a plasma discharge source.

14. The method of Claim 13 wherein said plasma discharge source is a radio-frequency or a direct-current plasma discharge source.

15. The method of Claim 1 wherein said amorphized region has a depth, as measured from an upper surface of the defective semiconductor crystal material, from about 1 to about 200 nm.

16. The method of Claim 1 wherein said amorphizing is performed by ion implantation using an ion dose of about 10^{12} to about 10^{16} atoms/cm^2.

17. The method of Claim 1 wherein said step of thermally treating is performed in an inert gas ambient.

18. The method of Claim 17 wherein said inert gas comprises He, Ar, N_2, Xe, Kr, Ne or mixtures thereof.

19. The method of Claim 17 wherein said inert gas ambient is diluted with an oxygen-containing gas.

20. The method of Claim 1 wherein said step of thermally treating is performed at a temperature of about 500°C or greater.

21. The method of Claim 1 wherein said step of thermally treating comprises a furnace anneal.

22. The method of Claim 21 wherein said furnace anneal is performed at a temperature of about 500°C or greater for a time period of about 15 minutes or greater.

23. The method of Claim 1 wherein said step of thermally treating comprises a rapid thermal anneal (RTA).

24. The method of Claim 23 wherein said RTA is carried out at a temperature of about 800°C or greater for a time period of about 10 minutes or less.

25. The method of Claim 1 wherein the step of thermally treating comprises a spike anneal.

26. The method of Claim 25 wherein the spike anneal is performed at a temperature of about 900°C or greater for a time period of about 5 seconds or less.

27. The method of Claim 1 wherein the step of thermally treating is performed to a single targeted temperature.

28. The method of Claim 1 wherein the step of thermally treating is performed using various ramp and soak cycles.

29. The method of Claim 1 wherein the steps of amophizing and thermally treating are repeated any number of times.

30. A method of improving the material quality of a defective semiconductor crystal material comprising the steps of:

introducing energetic ions into a region of a defective semiconductor crystal material to form an amorphous region within said defective semiconductor crystal material; and

heating the amorphized defective semiconductor crystal material to recrystallize said amorphized region forming a recrystallized region that has a reduced defect density as compared to the defective semiconductor crystal material.

31. A method of improving the material quality of a defective semiconductor crystal material comprising the steps of:

implanting energetic ions into a region of a defective semiconductor crystal material to form an amorphous region within said defective semiconductor crystal material, said implant is performed at an ion dose from about 10^{12}-10^{16} atoms/cm^2; and

heating the amorphized defective semiconductor crystal material to recrystallize said amorphized region forming a recrystallized region that has a reduced defect density as compared to the defective semiconductor crystal material, said heating is performed

using a rapid thermal anneal that is carried out a temperature of about 800°C or greater for a time period of about 10 minutes or less.